Diet and Seasonal Feeding Habits of the Yellow Stingray, Urolophus jamaicensis

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By

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I: Abstract

Urolophus jamaicensis, the yellow stingray, is a common elasmobranch found on and around the coral reefs off Florida's southeastern coast. Its diet consists of polychaetes, crustaceans, nemerteans, sipunculids, nematodes, and chaetognaths with polychaetes and crustaceans comprising almost 67% of the stomach contents by volume. There does not appear to be any diet preference between the male and females stingrays. The seasonal changes in diet preference are limited to an increase in the proportion of polychaetes found in the stomach during spring when compared to fall.

II: Introduction

The composition of the food of a species can provide information about the niche that the species occupies in its habitat (Berg, 1979). Therefore, stomach content analysis is a standard practice in fish ecology. Studies can estimate the total food consumption by a fish population or examine the diet of a species or both (Hyslop, 1980). The former is relevant since tropical carnivorous fishes strongly influence the distribution, density, and productivity of invertebrates. Such benthic invertebrate predators can, for example, account for up to 56% of the fish species found on coral reefs (Jones et al., 1991). Examination of the dietary components can be used to compare either different sub-groups of the same species or different species living in the same or similar habitats (Hyslop, 1980).

III: Objectives

The purpose of this study was to determine the diet and feeding habits of *Urolophus jamaicensis*, the yellow stingray in southeast Florida, in terms of amount, composition, and seasonality of food.

IV: Life History Summary

Urolophus jamaicensis, the yellow stingray is one of the rays in the family Urolophidae (Nelson, 1994). The genus *Urolophus* is represented by 15 species in the Indo-west Pacific, five species in the eastern Pacific and *U. jamaicensis* in the western Atlantic (Chirichigno and McEachran, 1979). The range of *U. jamaicensis* covers the western Atlantic Ocean from Florida (occasionally North Carolina) to the southern Caribbean and northern South America (Bigelow and Schroeder, 1953; Robins et al., 1986). These stingrays can be found along sandy beaches to the water's edge, and especially in sandy areas in and around coral reefs. *U. jamaicensis* is commonly found on and around coral reefs off the coast of Florida's Broward County.

Despite the frequency of occurrence, only one previous study (Yanez-Arancibia and Amezcua-Linares, 1979) has been conducted on *U. jamaicensis.* This was done in the Terminos Lagoon system, located in the Mexican province of Campeche, and focused on the ray's breeding and feeding behavior, and use of the lagoon as a nursery area. Little else has been done on *U. jamaicensis*, particularly its natural history, or even on *Urolophus* in general. Randall (1967) studied the diet of 212 species of fish around Puerto Rico and the Virgin Islands, but the yellow stingray was not one of them. Also, *U.*

jamaicensis was not documented among the fifteen species of elasmobranchs in the Indian River Lagoon System (Snelson and Williams, 1981). The Snelson and Williams study (1981) did include *Dasyatis americana* and *D. sabina*, both of which commonly share the habitat of the yellow stingray.

U. jamaicensis reportedly reaches 35 cm disk width and 66 cm total length (Robins et al., 1986) although most are smaller. The largest ray captured during this study was a female measuring 22.8 cm disk width and 42.2 cm total length. Yanez-Arancibia and Amezcua-Linares (1979) reported capturing 56 adult rays with the largest measuring 21.4 cm disk width and 41.0 cm total length.

Bigelow and Schroeder (1953) examined specimens of *U. jamaicensis* containing three and four embryos each and reported births of two or three young. Females, however, have been recorded with five embryos (Yanez-Arancibia and Amezcua-Linares, 1979; author, unpublished). Yanez-Arancibia and Amezcua-Linares (1979) state that parturition in *U. jamaicensis* occurs between May and October.

Little is known about the feeding behavior of *U. jamaicensis* although Robins et al. (1986) report the ray "raises the front end of disk, creating a dark crevice that attracts prey species seeking shelter." Bigelow and Schroeder (1953) wrote "... like their longer-tailed relatives of the family Dasyatidae, they are said to scoop out holes in the sand with their pectoral fins, thus dislodging worms and crustaceans on which they feed." Yanez-Arancibia and Amezcua-Linares (1979) did not report any observations on *U. jamaicensis* feeding behavior. *Narcine brasiliensis*, the lesser electric ray, is similar to *U. jamaicensis* in size, shape, range, and habitat, although it most often prefers sandy areas (Robins et al., 1986) such as the vicinity of barrier beach surf zones and bars adjacent to passes between estuarine barrier islands. Rudloe (1989a) noted prey-seeking behavior in *N. brasiliensis* as follows. Rays moved slowly over the substrate, they paused periodically, positioned themselves over one particular spot, and began to flutter the posterior pectoral fin margins. The rays then struck by lunging slightly forward and down, protruding the tubular mouth, and seizing a worm below the surface. Ingested sand was expelled through the spiracles. The fish then swam off the bottom and swallowed the worm in several gulps, after which searching resumed. I have observed a similar behavior in *U. jamaicensis* that was, presumably, feeding (author, unpublished).

A fish's diet provides information about the niche that the species occupies in its habitat (Berg, 1979). The diet of rays in general is varied and the feeding habits of dasyatids has been described as opportunistic (Struhsaker, 1969; Funicelli, 1975; Thorson, 1983; Gilliam and Sullivan, 1993). Teleosts, crustaceans, molluscs, annelids, sipunculids, nemerteans and plant material have been reported as food items in rays that are similar to *U. jamaicensis* or share its habitat. Bigelow and Schroeder (1953) reported that the stomach of one specimen of *U. jamaicensis* contained shrimp (*Penaeus brasiliensis*) and the stomach of another contained bottom detritus. Yanez-Arancibia and Amezcua-Linares (1979) reported that yellow rays ate different types of crustaceans, polychaetes, molluscs, amphipods and stomatopods. Pelecypods, polychaetes, and crustaceans compose over 94 percent of the total food content by volume for *U. halleri,* an eastern Pacific stingray, with bivalves the most important single class of food. The feeding habits of *U. halleri* change with age. Crustaceans form over one-half the food volume of the smallest rays, with annelids next in importance. As the rays increase in size, bivalves assume greater significance while annelids and crustaceans become relatively less important. This might be because the younger rays are unable to crush the shells of pelecypods (Babel, 1967). The diet of various size classes of *U. paucimaculatus,* from Port Phillip Bay on the southeastern coast of Australia, varies also, with amphipods and smaller quantities of isopods, polychaetes, caridean crustaceans, and mysids being consumed by rays up to 2 years of age (Edwards, 1980). Polychaetes were dominant in the diet of fish 3-4 years old while amphipods, carideans and isopods were of secondary importance. Specimens 4-7 years old and older showed a preference for carideans and polychaetes with the older fish also eating brachyurans (crabs) and teleost fish.

Rudloe (1989a) reported that the gut contents of 51 field-collected *N. brasiliensis* contained predominantly burrowing polychaetes, with occasional vermiform burrowing sipunculids or worm eels (family Ophichthidae). An additional 10 newborn *N. brasiliensis* had eaten juvenile polychaetes, anemones, nematodes, and burrowing amphipods.

Three members of the family Dasyatidae share the same habitat as the yellow stingray and stomach contents indicate that these rays feed on a wide variety of prey type and so are considered opportunistic feeders. *Dasyatis sayi,* and *D. sabina* feed on small crustaceans, especially mantis shrimp (*Squilla* sp.) and pistol shrimp (Alpheidae), and a variety of polychaete worms (Snelson and Williams, 1981). Hess (1961) found a diet of crustaceans, molluscs, annelids, and teleosts in specimens of *D. sayi* and *D. sabina* taken from Delaware Bay. Gilliam and Sullivan (1993) reported the diet of 18 *D. americana* taken from the Bahamas consisted of crustaceans, teleosts, molluscs, annelids, and plant material.

V: Methods

Thirty-one specimens of *Urolophus jamaicensis* were collected by pole-spear, using SCUBA, from the area surrounding the first and second reefs off Broward County, Fl. Dives were made from *Panacea*, a Phoenix 29 sport-fishing boat, or by walking out from the beach.

The stingrays were taken to the Nova Southeastern University Oceanographic Center for measurement and dissection. Measurements included total length, disk width, mouth to beginning of the cloacal slit, end of the cloacal slit to the tip of the tail and wet weight. Rays were opened on the ventral body midline from the pericardial cavity to the cloacal slit and stomachs were then injected with buffered 10% formalin. The pectoral girdle was cut to more easily remove the liver which was then discarded. Stomachs were tied off at each end, removed and preserved in the formalin solution for no less than two weeks. The stomachs were then stored in 40% isopropanol until examined. Stomachs were split open longitudinally, drained and the contents removed. The inside stomach wall was then rinsed with alcohol to ensure there was no remaining matter.

Stomachs contents were initially separated under a dissecting microscope and divided into ten categories for volumetric and numeric measurements, and taxonomic identification (when applicable): polychaetes (poly), crustaceans (crust), unidentified vermiforms (verm), nemerteans (nemer), sipunculids (sipun), holothuroids (holot), nematodes (nemat), chaetognaths (chaet), unidentifiable organic matter (u.o.m.), and unidentifiable inorganic matter (u.i.m.). Parts of, or partial, organisms that were distinct and could not be considered part of another organism found in the stomach were counted as individual specimens. Individual identifiable specimens removed from the stomachs are referred to as "items" in the following text, figures, and tables. Volumes by category were determined for each stomach to the nearest 0.05 ml by water displacement of the stomach contents in a 10 ml graduated cylinder. Volumes of items less than 0.05 ml were assigned a figure of 0.01 ml for the purpose of statistical analysis. Further identification to the lowest readily identifiable taxon was then accomplished under the dissecting microscope. Published keys were used in the identification of polychaetes (Smith and Carlton, 1975; Fauchald, 1977; Meinkoth, 1981; Banister and Campbell, 1985; Kaplan, 1988; Brusca and Brusca, 1990) and crustaceans (Manning, 1969; Smith and Carlton, 1975; Voss, 1976; McLaughlin, 1980; Meinkoth, 1981; Abele, 1982; Bliss, 1982; Banister and Campbell, 1985; Able and Kim, 1986; Kaplan, 1988; Brusca and Brusca, 1990). Dr. Charles Messing, Nova Southeastern University, assisted in the identification of nemerteans, sipunculans, holothuroids, nematodes and chaetognaths.

The following methods were used to quantify major prey taxa: 1) The volume (V), per stomach, of items of each group in milliliters, 2) The volume of items of each group expressed as a percentage (%V) of the total volume of stomach contents in milliliters, 3) The number of items (N) of each group, 4) The number of items of each group expressed as a percentage (%N) of the total number of stomach content items, 5) The frequency of occurrence (%F) expressed as a percentage of all stomachs that contained a certain item (Pinkas et al., 1971). These measurements were used to calculate an index of relative importance (IRI) :

$$IRI = \%F\ (\%N + \%V)$$

The greater the IRI number, the more important an item in the diet of the animal (Pinkas et. al., 1971).

All statistical analyses of the results were done on an IBM-compatible personal computer using Jandel Corporation's Sigmastat. Analyses of variance (ANOVA) (Sokal and Rohlf, 1981) were run on prey categories of all stomach contents combined, and by males and females separately. Post-ANOVA analyses to determine significant differences between means were done using the Student-Newman-Keuls Method (S-N-K) (Sokal and Rohlf, 1981). One-Way ANOVAs were run on four types of observations: 1) volume per prey category, 2) percent volume per prey category, 3) number of items per prey category and 4) percent number of items per prey category. Data was also separated by sex and t-tests were run on the same four types of observations between sexes.

To determine any seasonality in feeding trends, stomach contents were grouped according to month of collection. Volume was divided by total length to account for the size differences among rays. Due to the small sample size of rays per month, the months were grouped to provide a larger data base. Grouping was done five different ways to avoid artifical seasonal seperation of rays. ANOVAs were run among taxa within each group.

Monthly Groups:
1) Jan/Feb; March/April; May/June; July/Aug; Sept/Oct; Nov/Dec

2) Dec/Jan; Feb/March; April/May; June/July; Aug/Sept; Oct/Nov

3) Jan/Feb/March; April/May/June; July/Aug/Sept; Oct/Nov/Dec

4) Dec/Jan/Feb; March/April/May; June/July/Aug; Sept/Oct/Nov

5) Nov/Dec/Jan; Feb/March/April; May/June/July; Aug/Sept/Oct

VI: Results

Tables 1 and 2 show the stomach content analysis results by ray for volume and number, respectively. Representatives of 7 phyla, 13 orders, and 30 families were positively identified in the stomach contents of 31 yellow stingrays (Table 3). The total number of quantifiable items found in all stomachs was 894. Number of items per stomach ranged from 0 to 82 with an average of 28.7 items per ray. Most stomachs contained between 1 and 70 items (Fig. 1). Eighteen stingrays (58%) were below and thirteen stingrays (42%) were above the average. Only one stomach was empty except for a small amount (<0.05 ml) of unidentifiable organic matter. Quantifiable amounts of inorganic matter, mainly sand, were found in only five rays. The remaining stomachs contained only individual granules bound to organic matter.

Figures 2 through 7 show measures of the major prey taxa and stomach content categories. Polychaetes dominanted by V (35.6%, Figs. 2, 3) and N (35.2%, Figs. 4, 5) and occurred in 80.6% (Fig. 6) of the stomachs. Crustaceans were the next most dominant occurring in 87.1% (Fig. 6) of the stomachs with a %V of 31.1 (Fig. 3) and %N of 26.6 (Fig. 5). IRI results substantiate these findings with an IRI of 5715 for polychaetes and 5032 for crustaceans (Fig. 7). The remaining food groups were varied in their dominance and importance depending on the measure used. Unidentified

Table 1: Collection information and volumes (ml) of stomach content categories of *U. jamaicensis*. (Poly=Polychaetes; Crust=Crustaceans; Verm=Unidentified Vermiforms; Nemer=Nemerteans; Sipun=Sipunculids; Holot=Holothurids; Chaet=Chaetognaths; U.O.M.=Unidentifiable Organic Matter; U.I.M.=Unidentifiable Inorganic Matter).
*unknown (sex of the stingray was not recorded).

Ray #	Sex	Month	Poly	Crust	Verm	Nemer	Sipun	Holot	Nemat	Chaet	U.O.M	U.I.M
1	*unk.	Jul	0.5	0.2	0	0	0.1	0	0	0	0.65	0
2	F	Aug	0	0	0	0	0	0	0.01	0	0.01	0
3	F	Aug	0.7	0.6	0	0	0	0	0	0	0.3	0
4	M	Oct	0.1	0.2	0.15	0	0	0	0	0	1.8	0.01
5	F	Oct	0	0.1	0.05	0	0	0	0.01	0	0.1	0.01
6	F	Oct	0.4	0.5	0.1	0	0	0	0	0	0.2	0.01
7	M	Oct	0	0.01	0	0	0	0	0.01	0	0.01	0
8	F	Dec	0.05	0.05	0	0	0	0	0	0	0.01	0
9	M	Dec	0.2	0	0.01	0	0	0	0	0	0.35	0
10	F	Feb	0.2	0.15	0.05	0.01	0.05	0.1	0.01	0	0.05	0
11	F	Mar	0.3	0.4	0.15	0.1	0.25	0	0.01	0.01	0.25	0

Table 1: continued (Poly=Polychaetes; Crust=Crustaceans; Verm=Unidentified Vermiforms; Nemer=Nemerteans; Sipun=Sipunculids; Holot=Holothurids; Chaet=Chaetognaths; U.O.M.=Unidentifiable Organic Matter; U.I.M.=Unidentifiable Inorganic Matter).

Ray #	Sex	Month	Poly	Crust	Verm	Nemer	Sipun	Holot	Nemat	Chaet	U.O.M.	U.I.M.
12	M	Mar	0.55	0.85	0.4	0	0	0.15	0.01	0	0	0
13	M	Mar	0.75	0	0.1	0.1	0	0	0	0	0.01	0
14	F	Apr	1.1	0.6	0.15	0	0	0	0.01	0	0.15	0
15	F	May	0.65	0.2	0.05	0	0	0	0	0	0.05	0
16	M	May	0.8	0.2	0.15	0.05	0	0	0.1	0	0.1	0
17	F	Jun	0	0.05	0.05	0	0	0	0.01	0	0.05	0
18	F	Jun	1.3	0.25	0	0	0	0	0.01	0	0.2	0
19	M	Jul	0.3	0.55	0.1	0	0	0	0.01	0	0.1	0.01
20	F	Jul	0.35	0.05	0	0	0	0	0.01	0	0.1	0
21	M	Aug	0.8	0.35	0.2	0	0	0	0.01	0	0.55	0.25
22	F	Aug	0.7	0.3	0	0	0	0	0.05	0	0.3	0

Table 1: continued (Poly=Polychaetes; Crust=Crustaceans; Verm=Unidentified Vermiforms; Nemer=Nemerteans; Sipun=Sipunculids; Holot=Holothurids; Chaet=Chaetognaths; U.O.M.=Unidentifiable Organic Matter; U.I.M.=Unidentifiable Inorganic Matter).

Ray #	Sex	Month	Poly	Crust	Verm	Nemer	Sipun	Holot	Nemat	Chaet	U.O.M.	U.I.M.
23	F	Sep	0.45	1.5	0	0	0.3	0	0.01	0	0.25	0
24	M	Sep	0.05	3.75	0.2	0	0	0	0	0	0.01	0
25	M	Nov	0	0.05	0	0	0	0	0	0	0	0
26	F	Nov	0.2	0.05	0.9	0	0.55	0	0	0	0.3	0
27	F	Dec	0.5	0.7	0.1	0	0	0	0.01	0	0.25	0
28	F	Dec	0.7	0.9	0.15	0.05	0	0	0.15	0	0.25	0
29	M	Feb	1.6	0.05	0.3	0	0	0	0.01	0	0.2	0
30	F	Feb	1.2	0.01	0.2	0	0	0	0.5	0	0.2	0
31	M	Jan	0	0	0	0	0	0	0	0	0.01	0

Table 2: Collection information and number of items for each major prey category of *U. jamaicensis*. See Table 1 legend for definition of category abbreviations.
*unknown (sex of the stingray was not recorded).

Ray #	Sex	Month	Poly	Crust	Verm	Nemer	Sipun	Holot	Nemat	Chaet
1	unk*	Jul	7	3	0	0	3	0	0	0
2	F	Aug	0	0	0	0	0	0	1	0
3	F	Aug	7	1	0	0	0	0	0	0
4	M	Oct	6	4	5	0	0	0	0	0
5	F	Oct	0	16	1	0	0	0	5	0
6	F	Oct	16	4	1	0	0	0	0	0
7	M	Oct	0	2	0	0	0	0	2	0
8	F	Dec	2	47	0	0	0	0	0	0
9	M	Dec	4	0	1	0	0	0	0	0
10	F	Feb	9	15	4	1	2	1	5	0
11	F	Mar	16	13	4	6	3	0	2	2
12	M	Mar	11	18	9	0	2	2	3	0

Table 2: continued
See Table 1 legend for definition of category abbreviations.

Ray #	Sex	Month	Poly	Crust	Verm	Nemer	Sipun	Holot	Nemat	Chaet
13	M	Mar	1	0	1	2	0	0	0	0
14	F	Apr	9	5	1	0	0	0	53	0
15	F	May	14	2	8	0	0	0	0	0
16	M	May	8	1	2	1	1	0	20	0
17	F	Jun	0	1	2	0	0	0	1	0
18	F	Jun	24	3	0	0	0	0	30	0
19	M	Jul	9	19	2	0	0	0	2	0
20	F	Jul	5	1	0	0	0	0	3	0
21	M	Aug	52	4	8	0	0	0	5	0
22	F	Aug	31	27	0	0	0	0	24	0
23	F	Sep	4	13	0	0	2	0	8	0
24	M	Sep	2	19	0	0	0	0	0	0

Table 2: continued
See Table 1 legend for definition of category abbreviations.

Ray #	Sex	Month	Poly	Crust	Verm	Nemer	Sipun	Holot	Nemat	Chaet
25	M	Nov	0	1	0	0	0	0	0	0
26	F	Nov	5	1	3	0	2	0	0	0
27	F	Dec	14	6	5	0	0	0	1	0
28	F	Dec	10	9	9	1	0	0	6	0
29	M	Feb	44	1	19	0	0	0	2	0
30	F	Feb	5	2	3	0	0	0	49	0
31	M	Jan	0	0	0	0	0	0	0	0

Table 3: List of items identified from stomach contents of *U. jamaicensis*

* Animals not identified below this level.

Phylum Nemertea
*Nemerteans
Phylum Nematoda
*Nematodes
Phylum Annelida
Class Polychaeta
Order Orbiniida
*Paraonidae
Order Ctenodrilida
*Parergodrilidae
Order Spionida
*Spionidae
*Chaetopteridae
Order Opheliida
Opheliidae
Ammotrypane sp.
Armandia sp.
Order Capitellida
*Maldanidae
Order Phyllodocida
*Polynoidae
Pilargiidae
Parandalia sp.
*Syllidae
*Nereidae
*Glyceridae
Glycera sp.
Hemipodus sp.
*Goniadidae
Order Eunicida
Onuphidae
Onuphis sp.
Eunicidae
Marphysa sp.
Eunice sp.
Palola sp.
*Lumbrineridae
*Arabellidae

Table 3: continued

*Lysaretidae
*Order Terebellida
Phylum Sipuncula
*Sipunculids
Phylum Arthropoda
Class Malacostraca
Order Stomatopoda
*Lysiosquillidae
*Order Isopoda
Order Amphipoda
*Suborder Gammaridea
*Order Mysidacea
Order Decapoda
Suborder Dendrobranchiata
*Penaeidae
*Solenoceridae
Suborder Pleocyemata
Infraorder Caridea
*Alpheidae
*Hippolytidae
*Callianassidae
Palaemonidae
Palaemonetes pugio
*Pasiphaeidae
Processidae
Processa sp.
*Upogebiidae
Infraorder Brachyura
Dromiidae
Dromidia sp.
Calappidae
Calappa sp.
Majidae
Pitho spp.
Mithrax spp.
Pelia sp.
*Infraorder Anomura
Phylum Chaetognatha
*Chaetognaths
Phylum Echinodermata
Class Holothuroida
*Holothuroids

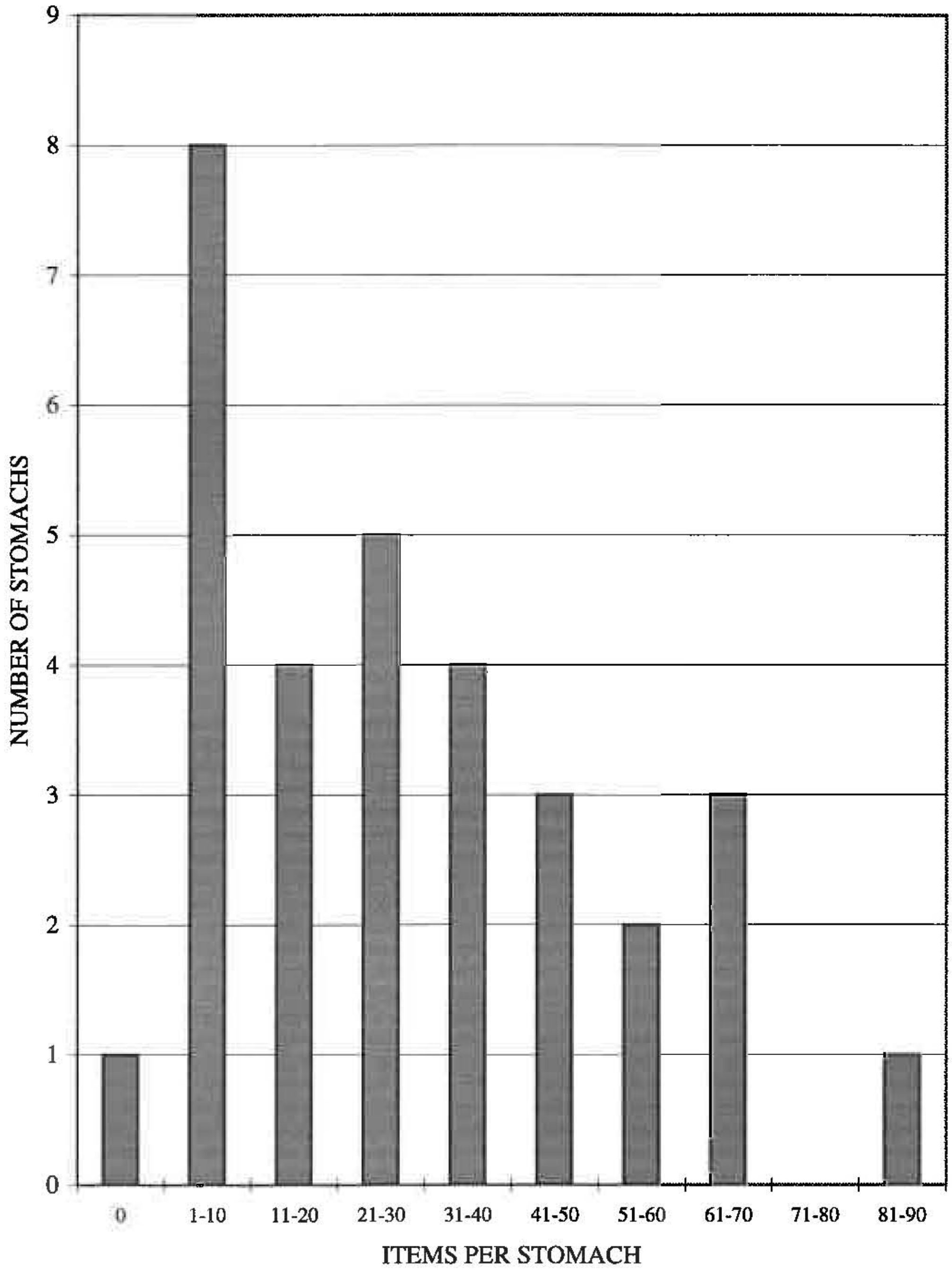

Figure 1: The distribution of food items in 31 ray stomachs.

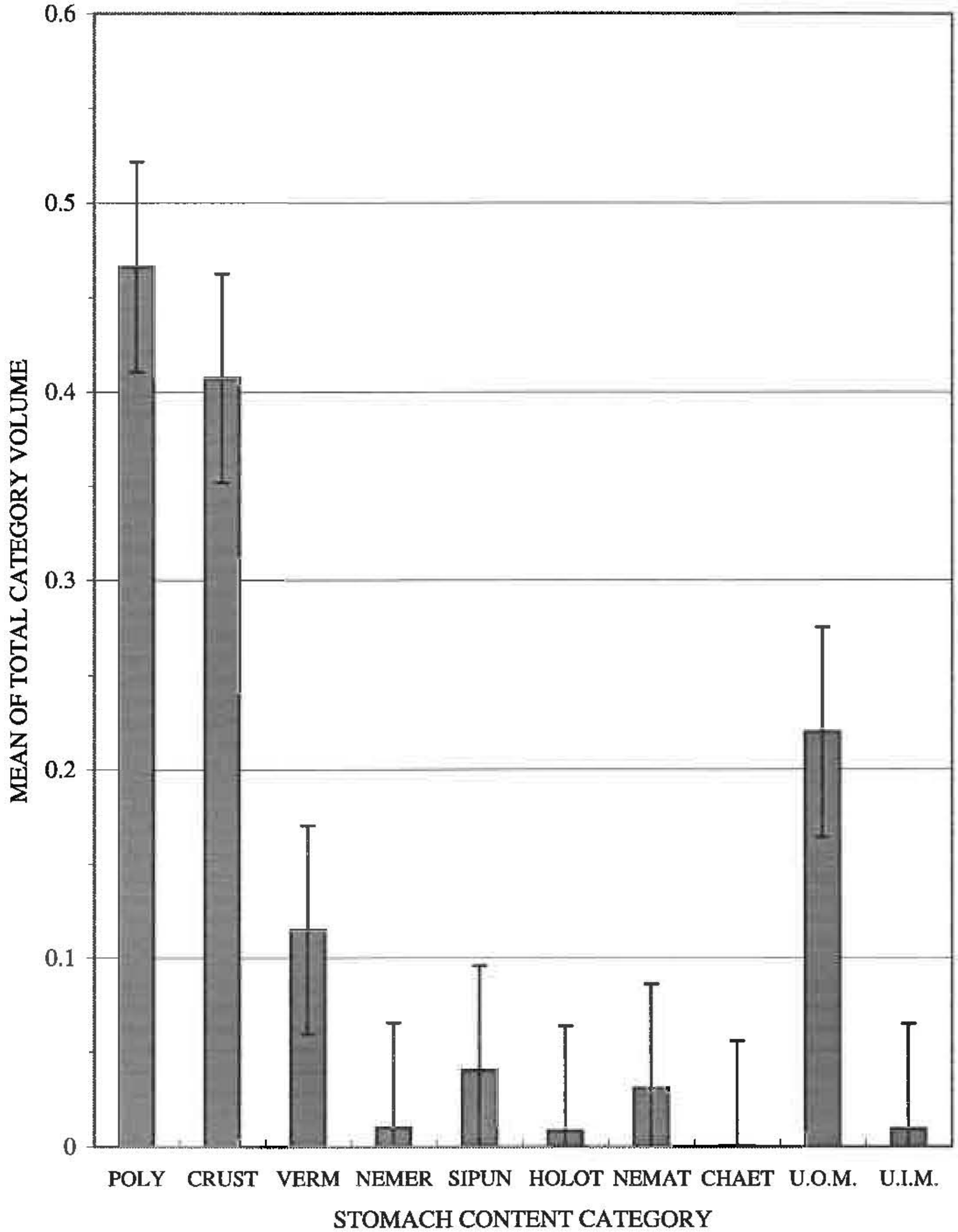

Figure 2: Mean and standard error for each category volume of stomach contents. See Table 1 legend for definition of category abbreviations.

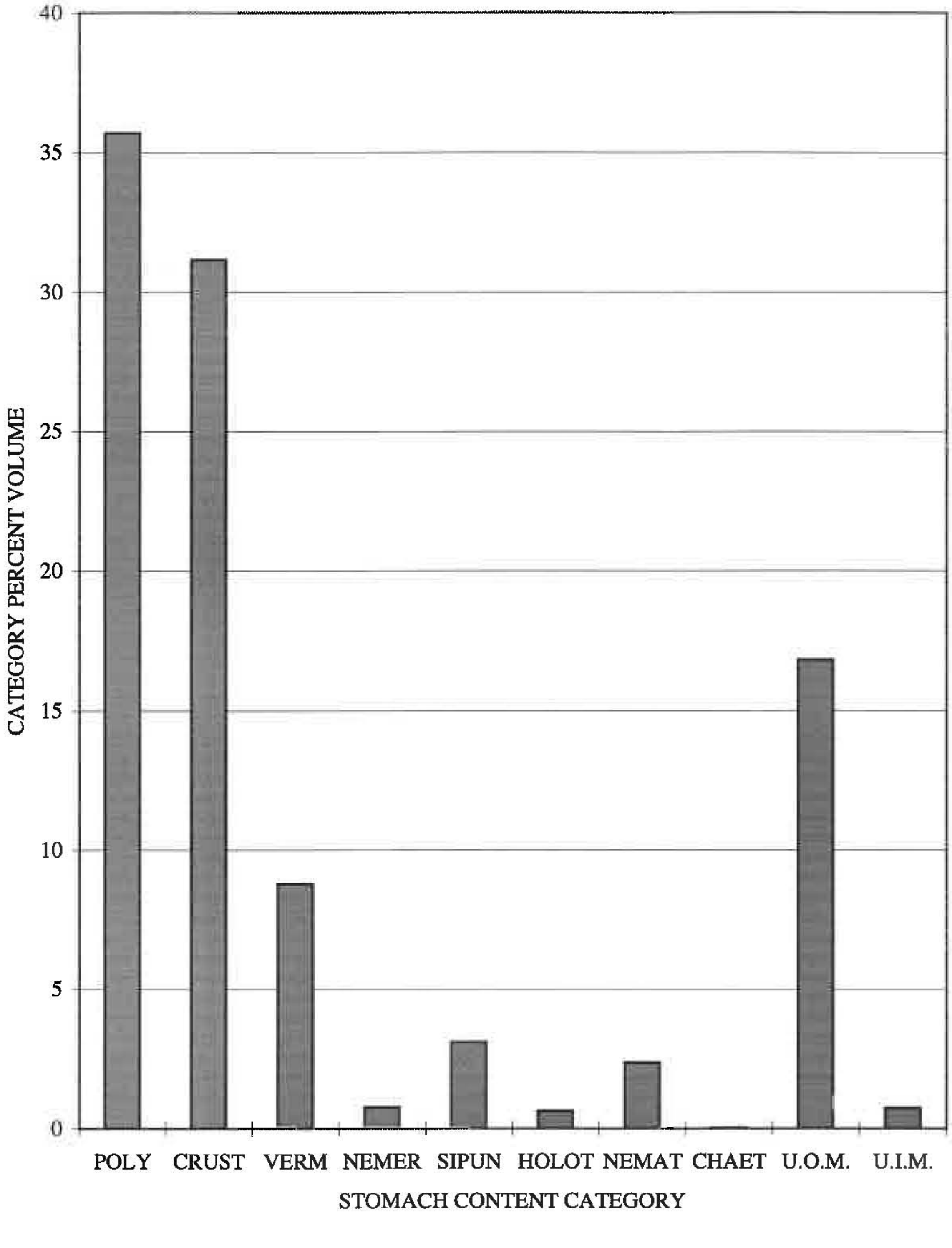

Figure 3: Percent volume of each category of the total stomach contents. See Table 1 legend for definition of category abbreviations.

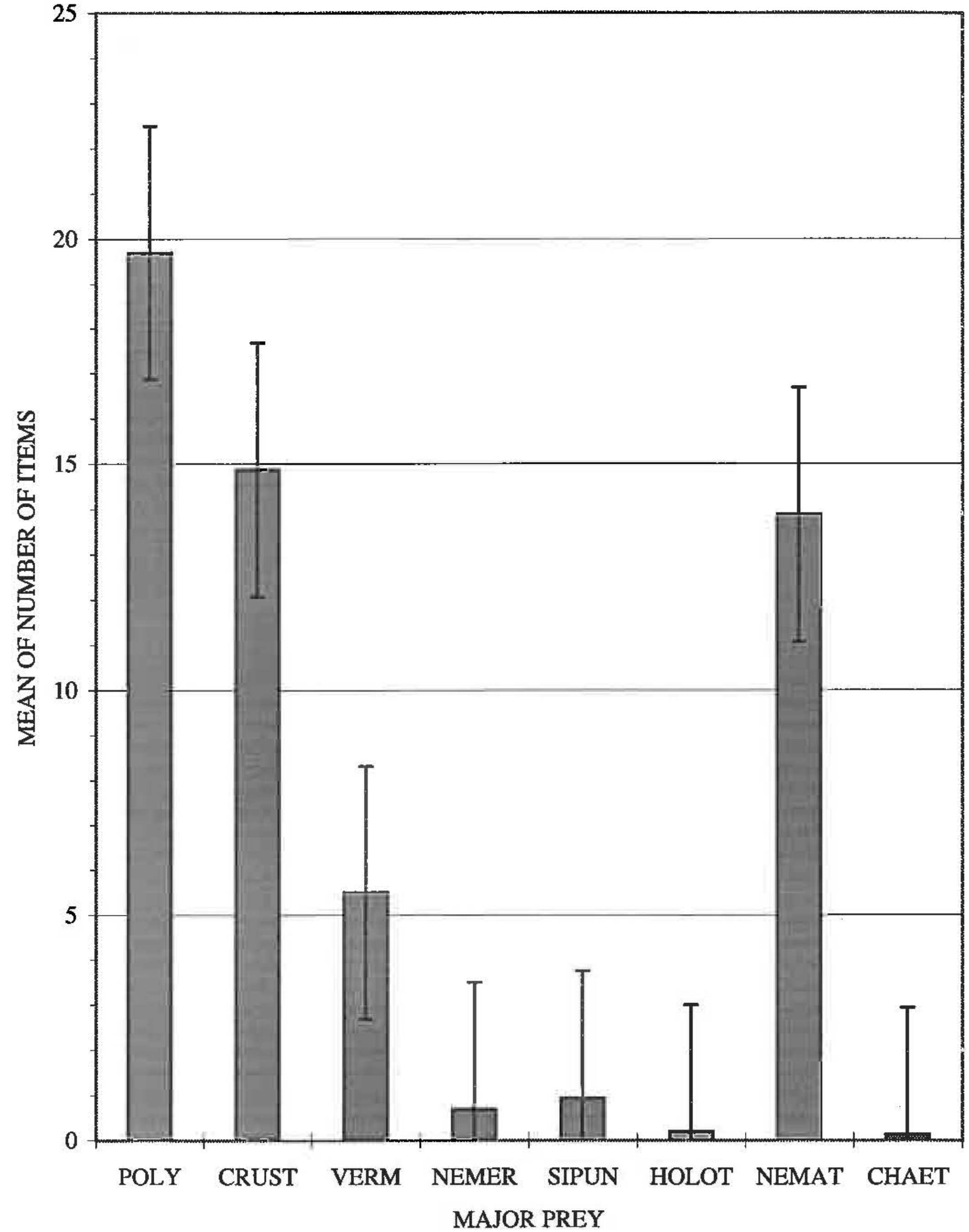

Figure 4: Mean and standard error for total number of items of each major prey category. See Table 1 legend for definition of category abbreviations.

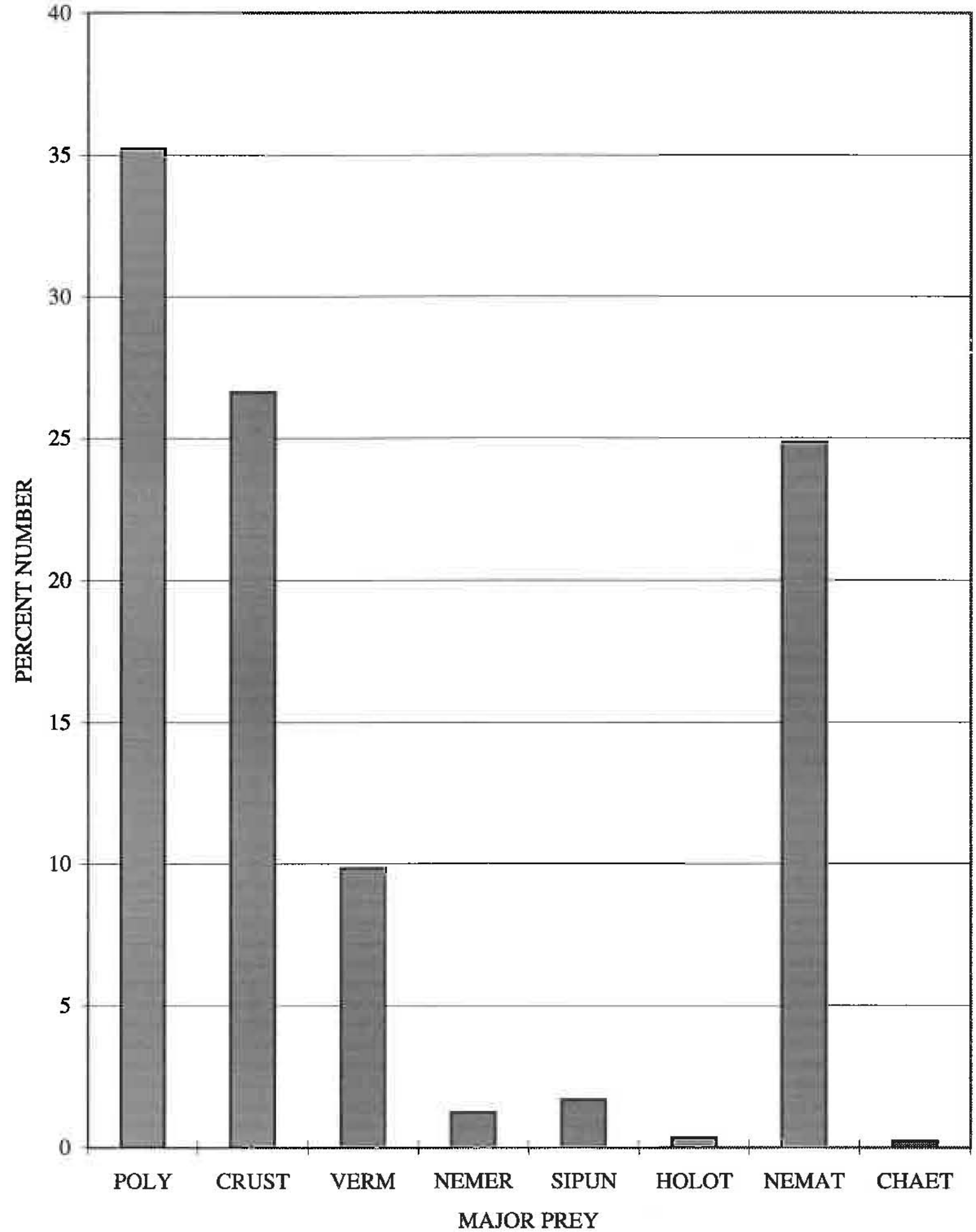

Figure 5: Percent of major prey categories of total stomach content items. See Table 1 legend for definition of category abbreviations.

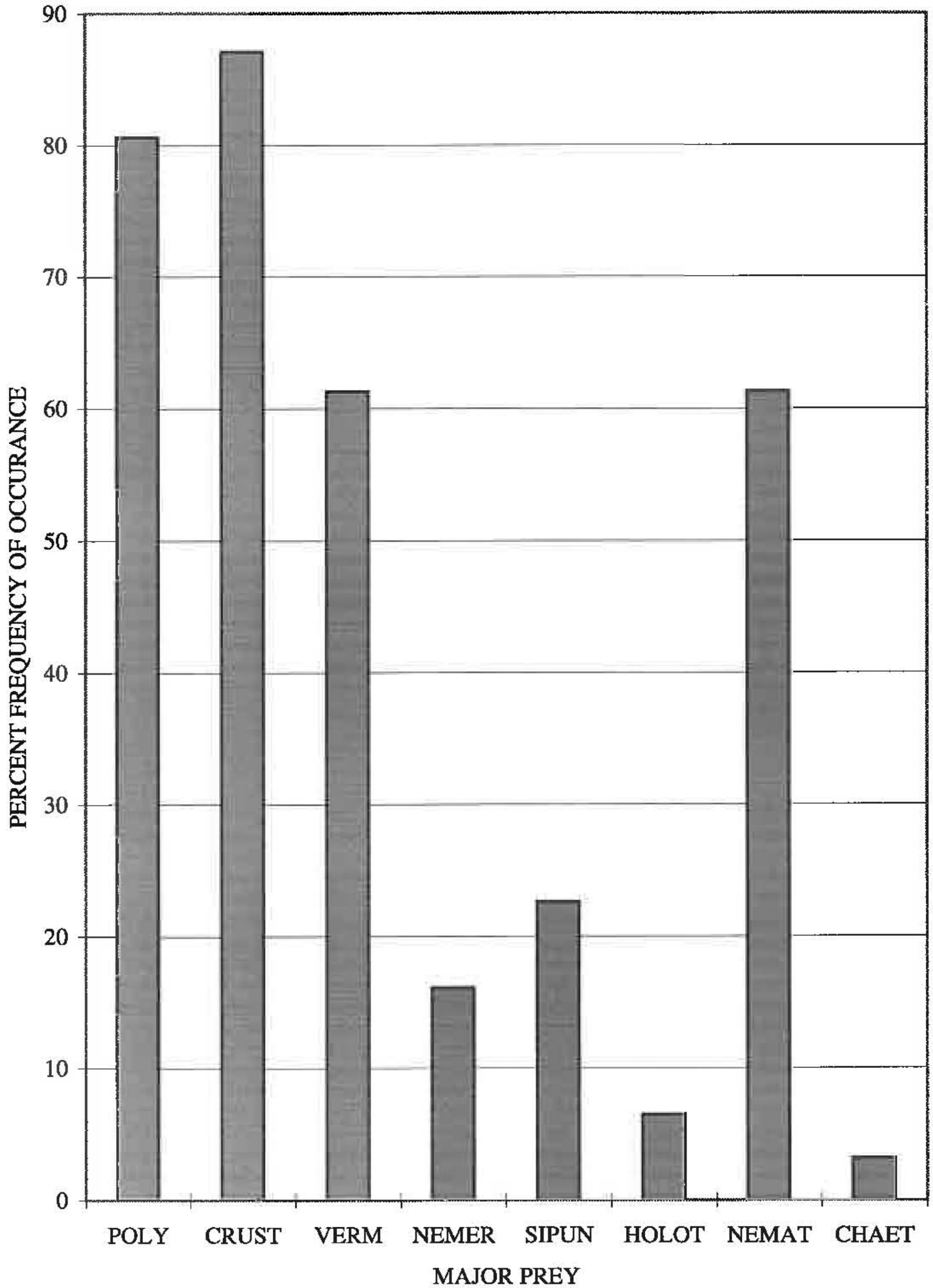

Figure 6: Frequency of occurance of major prey taxa in stomachs. See Table 1 legend for definition of category abbreviations.

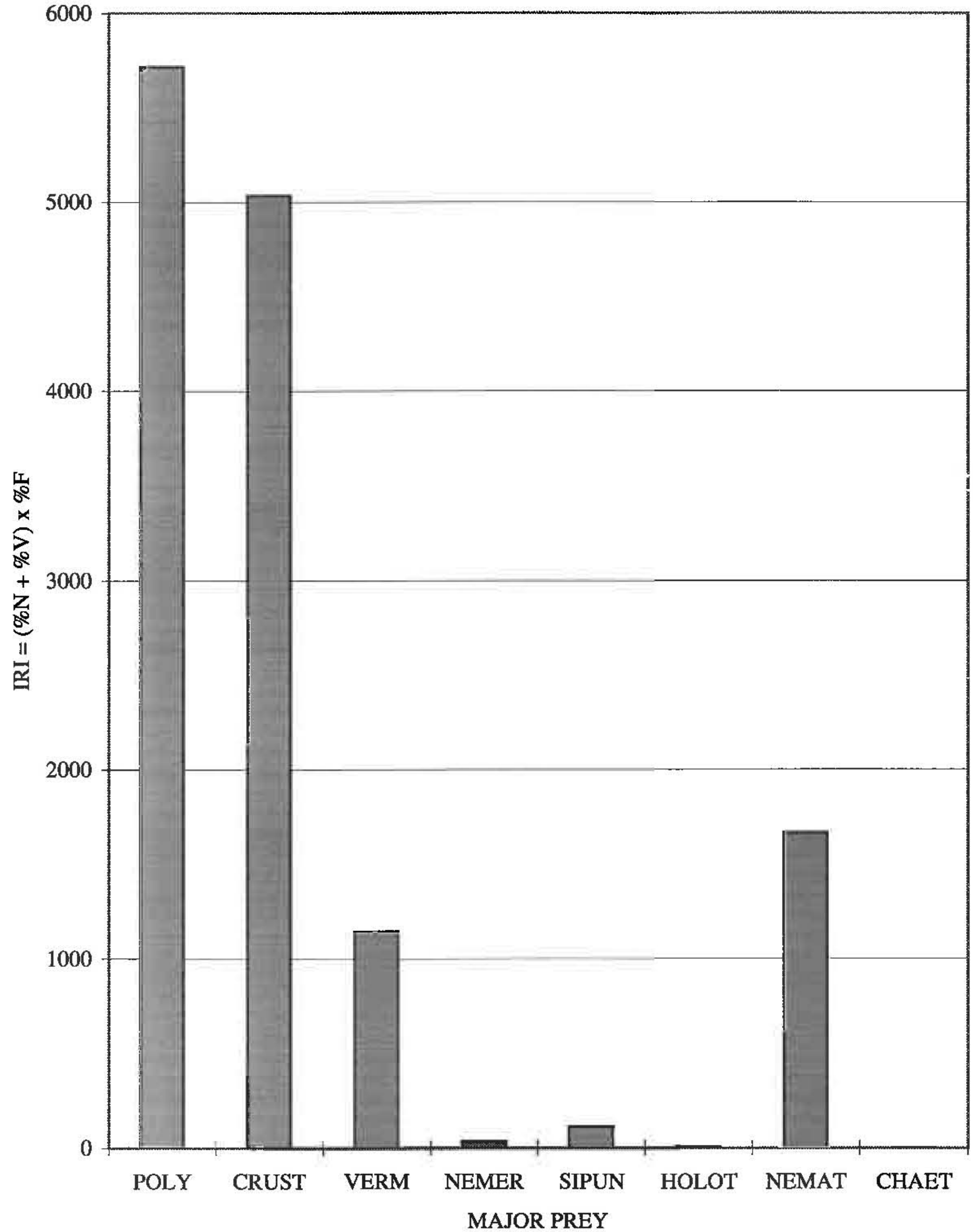

Figure 7: Index of Relative Importance of major prey categories. See Table 1 legend for definition of category abbreviations.

vermiforms (8.7%), sipunculids (3.0%), and nematodes (2.3%) would be the order according to %V (Fig. 3) while a measure of %N or IRI would change the order to nematodes (%N 24.8, Fig. 5; IRI 1666, Fig. 7), unidentified vermiforms (%N 9.8, Fig. 5; IRI 1142, Fig. 7), then sipunculids (%N 1.6, Fig. 5; IRI 107, Fig. 7). All three measures placed holothuroids and chaetognaths second to last and last in importance, respectively. Results for the total stomach contents are shown in Table 4.

Analysis of varience results indicated a significant difference ($P<0.05$) among prey categories for both volume and number. S-N-K results ($P < 0.05$) were varied when testing for a significant difference between food groups by volume and number (Table 5). The two dominant food groups, polychaetes and crustaceans, had no significant difference between means either by volume or number, but were different than all the other group means except unidentified organic matter (by volume). The group means of unidentified vermiforms and nematodes had no significant difference when compared with each other by number, but differed significantly from the other groups. The remaining groups (nemerteans, sipunculids, holothurids, and chaetognaths), had no significant difference among themselves when means were compared by volume or number.

Stomachs removed from male rays contained a total of 295 items with an average of 24.6 items. Number of items per stomach ranged from 0 to 69 with an average of 24.6 items per ray. Results of the stomach contents of male rays are shown in Table 6. Crustaceans were the dominant food group by volume (36.1%), followed by polychaetes (31.0%) and unidentified vermiforms (9.7%). Polychaetes, however, were the dominant

Table 4: Summary of Stomach Contents

STOMACH CONTENT	F	%F	V (ml)	%V	N	%N	IRI
POLYCHAETES	25	80.6	14.45	35.68	315	35.23	5,715
CRUSTACEANS	27	87.1	12.62	31.16	238	26.62	5,032
UNIDENTIFIED VERMIFORMS	19	61.3	3.56	8.79	88	9.84	1,142
NEMERTEANS	5	16.1	0.31	0.76	11	1.23	32
SIPUNCULIDS	7	22.6	1.25	3.09	15	1.68	107
HOLOTHURIDS	2	6.5	0.25	0.62	3	0.34	6
NEMATODES	19	61.3	0.95	2.35	222	24.83	1,666
CHAETOGNATHS	1	3.2	0.01	0.02	2	0.22	0.77
UNIDENTIFIABLE ORGANIC	29	93.6	6.81	16.81	N/A	N/A	N/A
UNIDENTIFIABLE INORGANIC	5	16.1	0.29	0.72	N/A	N/A	N/A

Table 5: Student-Newman-Keuls results for significant differences between food category means. Categories in the same underlined group are not significantly different (P>0.05). See Table 1 legend for definition of category abbreviations.

Volume per prey category:

Poly Crust U.O.M. Verm Nemat Nemer Sipun Holot Chaet U.I.M.

Percent Volume per prey category:

Poly Crust U.O.M. Verm Nemat Nemer Sipun Holot Chaet U.I.M.

Number of items per prey category:

Poly Crust Verm Nemat Nemer Sipun Holot Chaet

Percent Number of items per prey category:

Poly Crust Verm Nemat Nemer Sipun Holot Chaet

Table 6: Summary of Stomach Contents for Male Rays

STOMACH CONTENT	F	%F	V (ml)	%V	N	%N	IRI
POLYCHAETES	9	75.0	5.15	31.0	137	46.4	5,805
CRUSTACEANS	9	75.0	6.01	36.1	69	23.4	4,462
UNIDENTIFIED VERMIFORMS	9	75.0	1.61	9.7	47	15.9	1,920
NEMERTEANS	2	16.7	0.15	0.9	3	1.0	31
SIPUNCULIDS	2	16.7	0.02	0.1	3	1.0	18
HOLOTHURIDS	1	8.3	0.15	0.9	2	0.7	13
NEMATODES	6	50.0	0.15	0.9	34	11.5	620
CHAETOGNATHS	0	0.0	0.00	0.0	0	0.0	0
UNIDENTIFIABLE ORGANIC	10	83.3	3.14	18.9	N/A	N/A	N/A
UNIDENTIFIABLE INORGANIC	3	25.0	0.27	1.6	N/A	N/A	N/A

food group by number (46.4%) and IRI (5805), followed by crustaceans with a %N of 23.4 and an IRI of 4462. Unidentified vermiforms were next with a %N of 15.9 and an IRI of 1920. All three food groups were found in 75% of the stomachs removed from the male rays.

ANOVA results indicated a significant difference ($P<0.05$) between major prey categories of male rays. S-N-K results for %V for males did not indicate a significant difference ($P>0.05$) between group means of polychaetes, crustaceans, unidentifiable vermiforms, and unidentifiable organic material. These four groups did show a significant difference ($P<0.05$) when compared with the means of the remaining groups. There was no significant difference among the nemerteans, sipunculids, holothurids, nematodes, and unidentifiable inorganic matter. S-N-K results for %N indicated the same significant differences between the same groups as above (with the exception of organic and inorganic material which could not be tested). Student-Newman-Keuls results for significant differences between food group means of male rays are shown in Table 7.

Stomachs removed from female rays contained a total of 586 items with an average of 32.5 items. Number of items per stomach ranged from 1 to 82 with an average of 32.5 items per ray. Results for the stomach contents of female rays are shown in Table 8. Polychaetes were the dominant food group in females by V (39.2%), N (29.2%) and IRI (5697) and occurred in 83.3% of the stomachs. Crustaceans followed, occurring in 94.4% of the stomachs with a %V of 28.6, %N of 28.3, and an IRI of 5371. Nematodes were the third most dominant food group, occurring in 72.2% of the stomachs with a %V of 3.6, %N of 32.1 and an IRI of 2577.

Table 7: Student-Newman-Keuls results for significant differences between food category means of male rays. Categories in the same underlined group are not significantly different ($P>0.05$). See Table 1 legend for definition of category abbreviations.

Volume per prey category:

Poly Crust U.O.M. Verm   Nemat Nemer Sipun Holot Chaet U.I.M.

Percent Volume per prey category:

Poly Crust U.O.M. Verm   Nemat Nemer Sipun Holot Chaet U.I.M.

Number of items per prey category:

Poly Crust Verm   Nemat   Nemer Sipun Holot Chaet

Percent Number of items per prey category:

Poly Crust Verm   Nemat   Nemer Sipun Holot Chaet

Table 8: Summary of Stomach Contents for Female Rays

STOMACH CONTENT	F	%F	V (ml)	%V	N	%N	IRI
POLYCHAETES	15	83.3	8.80	39.20	171	29.2	5,697
CRUSTACEANS	17	94.4	6.41	28.60	166	28.3	5,371
UNIDENTIFIED VERMIFORMS	11	61.1	1.95	8.70	41	7.0	959
NEMERTEANS	3	16.7	0.16	0.70	8	1.4	35
SIPUNCULIDS	4	22.2	1.15	5.10	9	1.5	146
HOLOTHURIDS	1	5.5	0.10	0.40	1	0.2	3
NEMATODES	13	72.2	0.80	3.60	188	32.1	2,577
CHAETOGNATHS	1	5.5	0.01	0.04	2	0.3	1
UNIDENTIFIABLE ORGANIC	18	100	3.02	14.50	N/A	N/A	N/A
UNIDENTIFIABLE INORGANIC	2	11.1	0.02	0.10	N/A	N/A	N/A

ANOVA results indicated a significant difference ($P<0.05$) between major prey groups of female rays. S-N-K results for %V of female rays did not indicate a significant difference between group means for polychaetes, crustaceans and unidentifiable organic matter. These three groups, however, along with nematodes, did show a significant difference when compared with the means for the remaining groups. There was not a significant difference among nemerteans, sipunculids, holothurids, chaetognaths, and unidentifiable inorganic matter.

S-N-K results for %N of female rays did not indicate a significant difference between the polychaetes, crustaceans, and nematodes group means. These three groups did show a significant difference when compared with the means of the remaining groups (nemerteans, sipunculids, holothurids and chaetognaths). There was no significant difference between nemerteans, sipunculids, holothurids and chaetognaths. Student-Newman-Keuls results for significant differences between food group means of female rays are show in Table 9.

T-test results between the male and female rays for V, %V, N, and %N, showed no significant differences ($P>0.05$) between the amounts of the same major food groups.

Polychaetes were the only major food group to show any significant difference with seasonality (Fig. 8). ANOVA results indicated that the rays were eating greater amounts of polychaetes in the spring (March/April) and significantly less in the fall (October/November). Student-Newman-Keuls results for seasonality analyses are shown in Table 10.

Table 9: Student-Newman-Keuls results for significant differences between food category means of female rays. Categories in the same underlined group are not significantly different (P>0.05).See Table 1 legend for definition of category abbreviations.

Volume per prey category:

Poly Crust U.O.M. Nemat Verm Nemer Sipun Holot Chaet U.I.M.

Percent Volume per prey category:

Poly Crust U.O.M. Nemat Verm Nemer Sipun Holot Chaet U.I.M.

Number of items per prey category:

Poly Crust Nemat Verm Nemer Sipun Holot Chaet

Percent Number of items per prey category:

Poly Crust Nemat Verm Nemer Sipun Holot Chaet

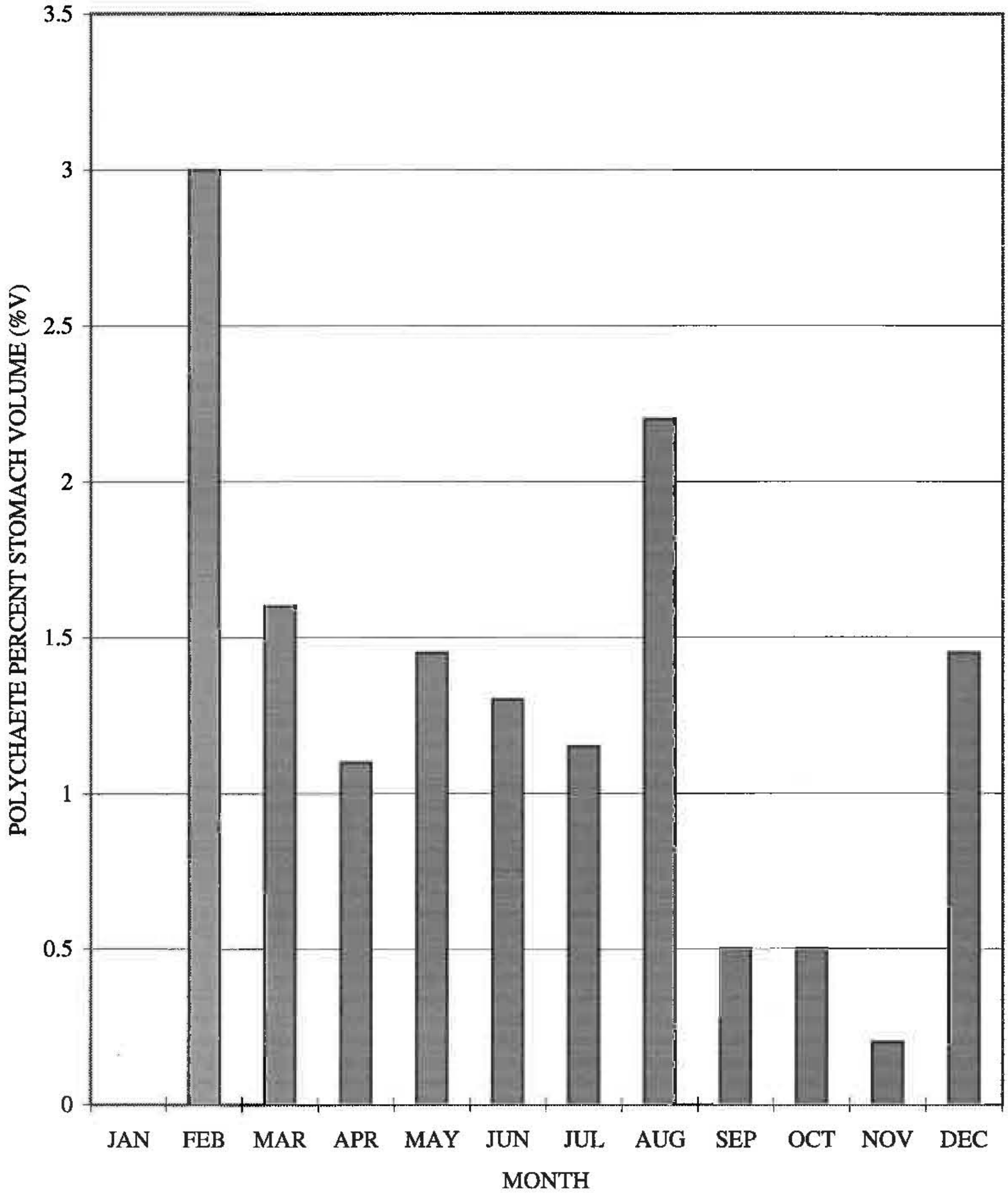

Figure 8: Total percent volume of polychaetes per month.

Table 10: Student-Newman-Keuls results for seasonality analyses. Categories in the same underlined group are not significantly different (P>0.05). See Table 1 legend for definition of category abbreviations.

1st Monthly Grouping:

Jan/Feb Mar/Apr May/Jun Jul/Aug Sep/Oct Nov/Dec

2nd Monthly Grouping:

Dec/Jan Feb/Mar Apr/May Jun/Jul Aug/Sep Oct/Nov

3rd Monthly Grouping:

Jan/Feb/Mar Apr/May/Jun Jul/Aug/Sep Oct/Nov/Dec

4th Monthly Grouping:

Sep/Oct/Nov Dec/Jan/Feb Jun/Jul/Aug Mar/Apr/May

5th Monthly Grouping:

Feb/Mar/Apr May/Jun/Jul Aug/Sep/Oct Nov/Dec/Jan

VII: Discussion:

Many feeding theory models predict that the greater the absolute abundance of food, the smaller the range of items that should be taken (Schoener, 1971). An animal eating a limited prey selection, determined by stomach content analysis, is considered a specialist. An animal is said to be more generalized in its selection of prey types if it eats a greater range or variance of food types and "type" is used to mean any prey item that can be recognized by the fish as being distinct (Pitcher, 1993). Jones et al. (1991), however, states that dietary items must be distinguished to the species level in order to categorize fish predators as generalists or specialists. *N. brasiliensis* were able to distinguish between polychaetes from different families, feeding more readily on *Glycera dibranchiata* than on *Arenicola cristata* and *Nereis virens,* but were often unable to detect and attack live polychaetes that were not at least partially buried (Rudloe, 1989a). The fish did not attack non-living or non-vermiform items, were totally unreceptive to any type of dead food and worms that were inactive, or moving weakly and burrowing slowly, appeared to be less attractive to rays than vigorously moving worms (Rudloe, 1989a). Efforts to feed the electric ray (*Torpedo ocellata*) any type of dead prey were also unsuccessful (Michaelson, 1979). Specimens of *U. jamaicensis* kept alive at the N.S.U. Oceanographic Center for several months fed readily on frozen shrimp (author, unpublished). It appears that controlled experimental studies rather than stomach content analyses are needed to determine whether a fish is a generalist or specialist and at what "level" a prey type would be considered different.

The specimens of *U. jamaicensis* examined in this study fed mainly on polychaetes and crustaceans, with these two food groups totaling 66.84% of the stomach contents by volume. Most of the remaining stomach content volume consisted of unidentified organic matter and unidentified vermiforms totaling 26.6%. In comparison, Yanez-Arancibia and Amezcua-Linares (1979) found that the rays from the Terminos Lagoon estuary in the southern Gulf of Mexico fed mainly on polychaetes, crustaceans and molluscs, with these three groups totaling up to 82% of the diet. The remaining volume was unidentified organic matter (18-25%).

Babel (1967) reported that, out of eight major food categories, pelecypods, polychaetes, and crustaceans, comprised over 94% of the stomach contents by volume of *U. halleri*. Polychaetes accounted for 30.42% and crustaceans for 21.38% of total food volume. The remaining groups were considered merely incidental to the ray's diet.

A major source of error in stomach content analysis is the damage caused by mastication and the varying rates of digestion of different food organisms resulting in unidentifiable organic matter. This will bias the data toward less digestible organisms (Randall, 1967). In some specimens of *U. jamaicensis,* unidentifiable organic matter can make up 25% of the total volume content (Yanez-Arancibia and Amezcua-Linares, 1979). Many of the polychaetes found in the stingray stomachs were damaged and most specimens were identified using only the head and a limited number of anterior segments. Many crustaceans, mainly stomatopods and brachyurans, were identified by examining empty carapaces. Much of the unidentifiable organic matter was cohesive clumps that could have been damaged polychaete segments or crustacean flesh. Thus, the percentage of stomach contents reported here as polychaetes and crustaceans should be considered conservative.

Nematodes, while numerous in some individuals (51 being found in one stomach) appear to be a minor food type (2.3% by volume). Rudloe (1989a) reported 10 newborn lesser electric rays had eaten nematodes, but no further details of the prey's condition was mentioned. All nematodes found in the stomachs of *U. jamaicensis* were in excellent condition with no signs of digestion and could have been parasitic or the result of incidental ingestion since nematode-infected polychaetes and crustaceans were found in the stingray stomachs.

Nemerteans, sipunculids, and holothuroids are minor food types with only 26 specimens found in all stomachs with a combined stomach content volume of 4.47%. Only two specimens of chaetognaths were found in the 31 stingrays examined.

In many fishes extraneous material or unwanted detritus can be rejected through the gill openings or ejected through the mouth with a "coughing" action (Bond, 1979). Apparently *U. jamaicensis* can do likewise. The small amount of inorganic matter found in the stomachs may derive from the digestion of sand-filled polychaetes; most of the sand granules had organic matter attached to the surfaces.

A higher presence of a particular food type in a diet could result either from a strong preference or from a high abundance of the food item in the potentially available food (Berg, 1979). Grassle (1973) mentions the collection of over 100 polychaete species from a single patch of coral rubble. In this study, polychaete and crustacean means were significantly higher than the means of any of the other major food taxa.

Statistical analysis of major food groups did not identify any food item preference between sexes. Yanez-Arancibia and Amezcua-Linares (1979) did not discuss sexual preference of food items for *U. jamaicensis* found in the Terminos Lagoon system.

Yanez-Arancibia and Amezcua-Linares (1979) found the %V of polychaetes ranged from 43% to 32% in specimens of *U. jamaicensis* depending on the season. Many rays are known to have seasonal distributions and move to deeper water in the winter (Struhsaker, 1969; Talent, 1985; Snelson et al., 1988; Rudloe, 1989b). *U. jamaicensis* was much less common in the study areas during the winter months and an independent study suggests that distribution of the yellow stingray may be seasonal (Sulikowski, 1996). Statistical analyses indicate a greater amount of polychaetes consumed in the fall than in the spring. This change in feeding habits apparently coincides with a change in habitat. However, a full examination of the ray's seasonal movements and prey abundance in different habitats would be required to confirm any relationship. None of the other food groups showed any seasonal difference in volume.

VIII: Conclusions

U. jamaicensis feed on a wide variety of animals which would categorize the ray as a generalist predator. Polychaetes and crustaceans are the two dominant food groups for the stingrays examined and the other groups (nemerteans, sipunculids, nematodes, and chaetognaths) are most probably incidental to the ray's diet. Female and male yellow stingrays feed equally on the same food groups.

U. jamaicensis eat fewer polychaetes in the fall season than the spring season. This could be a result of their migratory habits of moving to deeper water in the colder months. The seasonal difference in polychaetes found in the stomachs might be the result of fewer polychaetes in the habitat or the rays spending less time foraging in the sediment.

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X: References

Abele, L.G. 1982. Vol. 1. The Biology of Crustacea: Systematic, the Fossil Record, and Biogeography. Academic Press, New York. 319 pp.

Abele, L.G. and W. Kim. 1986. An illustrated guide to the marine decapod crustaceans of Florida. Florida Dept. of Envir. Reg. Tech. Ser. 8.

Babel, J.S. 1967. Reproduction, life history and ecology of the round stingray *Urolophus halleri* Cooper. Fish. Bull. Calif. 137: 1-104.

Banister, K. and A. Campbell, ed. 1985. Encyclopedia of Aquatic Life. Facts on File Inc. New York. 349 pp.

Berg, J. 1979. Discussion of Methods of Investigation the Food of Fishes, with Reference to a Preliminary Study of the Prey of *Gobiusculus flavescens* (Gobiidae). Marine Biology 50:263-273.

Bliss, D.E. 1982. Shrimps, lobsters, and crabs. Columbia Univ. Press. New York. 242 pp.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the western North Atlantic. Part two: sawfishes, guitarfishes, skates, and rays. Mem. Sears Found. Mar. Res. 1(2). 558 pp.

Bond, C.E. 1979. Biology of Fishes. Saunders College Publishing. Philadelphia. 514 pp.

Brusca, R.C. and G.B. Brusca. 1990. Invertebrates. Sinauer Associates Inc. Sunderland. 922 pp.

Chirichigno, N.F. and J.D. McEachran. 1979. *Urolophus tumbesensis*, a new stingray from the coast of Peru (batoidea:Urolophidae). Copeia 4:709-713.

Edwards, R.R.C. 1980. Aspects of the Population Dynamics and Ecology of the White Spotted Stingraee, *Urolophus paucimaculatus* Dixon, in Port Phillip Bay, Victoria. Aust. J. Mar. Freshwater Res. 31: 459-467.

Fauchald, K. 1977. The Polychaete worms; Definitions and keys to the orders, families and genera. Natural History Museum of Los Angeles County, Los Angeles. 188 pp.

Funicelli, N.A. 1975. Taxonomy, feeding, limiting factors, and sex ratios of *Dasyatis sabina, Dasyatis americana, Dasyatis sayi,* and *Narcine brasiliensis*. Ph.D. Dissertation, Univ. S. Miss., Hattiesburg, Mississippi. 258 pp.

Gilliam, D. and K.M. Sullivan. 1993. Diet and feeding habits of the Southern Stingray, *Dasyatis americana*, in the Central Bahamas. Bull. Mar. Sci. 52(3):1007-1013.

Grassle, J.F. 1973. Variety in coral reef communities. In Marine Ecology, J.S. Levington (ed.). Prentice-Hall Inc. Englewood Cliffs, pp. 437-438.

Hess, P.W. 1961. Food habits of two Dasyatid rays in Delaware Bay. Copeia 1961: 239-241.

Hyslop, E.J. 1980. Stomach content analysis-a review of methods and their application. J.Fish Biology. 17:411-429.

Jones, G.P., D.J.Ferrell, and P.F. Sale. 1991. Fish predation and its impact on the invertebrates of coral reefs and adjacent sediments. In: The Ecology of Fishes on Coral Reefs, P.F. Sale (ed.). Academic Press, San Diego, pp. 156-179.

Kaplan, E.H. 1988. Peterson's Guide; A Field Guide to Southeastern and Caribbean Seashores. Houghton Mifflin Co. Boston. 425 pp.

Manning, R.B. 1969. Stomatopod Crustacea of the Western Atlantic. Univ. of Miami Press. Coral Gables. 380 pp.

McLaughlin, P.A. 1980. Comparative Morphology of Recent Crustacea. W.H. Freeman and Co. San Francisco. 177 pp.

Meinkoth, A.N. 1981. Audubon Society Field Guide to North American Seashore Creatures. Alfred A. Knopf, New York. 798 pp.

Michaelson, D.S. 1979. Observations on feeding , growth and electric discharge of newborn *Torpedo ocellata* (chondrichthyes, batoidei). J.Fish. Biol. 15:159-163.

Nelson, J.A. 1994. Fishes of the World. Academic Press, New York. 523 pp.

Pinkas, L., M.S. Oliphant and I.L.K.Iverson. 1971. Food habits of albacore, bluefin tuna and bonito in California waters. Calif. Dep. Fish Game Bull. 152:1-105.

Pitcher, T.J. 1993. Behaviour of Teleost Fishes. Chapman and Hall. London. 465 pp.

Randall, J.E. 1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr. 5:665-847.

Robins, C.R. G.C. Ray, and J. Douglas. 1986. A Field Guide to Atlantic Coast Fishes of North America. Houghton Mifflin Co. Boston. 354 pp.

Rudloe, A. 1989a. Captive maintenance of the lesser electric ray, with observations of feeding behavior. Progressive Fish Culture 51:37-41.

Rudloe, A. 1989b. Habitat preferences, movement, size frequency patterns and reproductive seasonality of the lesser electric ray, *Narcine brasiliensis*. Northeast Gulf Sci. Vol 10 2:103-112.

Schoener, T.W. 1971. Theory of feeding strategies. Ann. Rev. Ecol. Syst. Vol.2:369-404.

Smith, R.I. and J.T. Carlton, eds. 1975. Light's Manual: Intertidal Invertebrates of the Central California Coast. 3rd ed. Univ. of California Press. Berkley. 717 pp.

Snelson, Jr., F.F. and S.E. Williams. 1981. Notes on the Occurrence, Distribution, and Biology of Elasmobranch Fishes in the Indian River Lagoon System. Estuaries 4:110-120.

Snelson, Jr., F.F., S.E. Williams-Hooper and T.H. Schmid. 1988. Reproduction and Ecology of the Atlantic Stingray, *Dasyatis sabina*, in Florida Coastal Lagoons. Copeia 3:729-739.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry: The Principles and Practice of Statistics in Biological Research. 2nd ed. W. H. Freeman and Co. New York. 887 pp.

Struhsaker, P. 1969. Observations on the biology and distribution of the thorny stingray, *Dasyatis centroura*. (Pisces:Dasyatidae). Bull. Mar. Sci. 19:456-481.

Sulikowski, J. 1996. Preliminary study on the population density, size distribution, age, and growth of *Urolophus jamaicensis* in southeastern Florida. Master's Thesis. N.S.U. Oceanographic Center. Dania, Fl.

Talent, L. G. 1985. The Occurrence, Seasonal Distribution, and Reproduction of Elasmobranch Fishes in Elkhorn Slough, California. Calif. Fish and Game 71: 210-219.

Thornson, T.B. 1983. Observations on the morphology, ecology, and life history of the euryhaline stingray, *Dasyatis guttata* (Bloch and Schneider) 1801. Acta Biol. Veniz. 11:95-125.

Voss, G.L. 1976. Seashore Life of Florida and the Caribbean. A Guide to the Common Marine Invertebrates and Plants of the Atlantic from Bermuda and the Bahamas to the West Indies and the Gulf of Mexico. Banyan Books, Inc. Miami. 199 pp.

Yanez-Arancibia, A. and F. Amezcua-Linares. 1979. Ecology of *Urolophus jamaicensis* (Cuvier) in the Terminos Lagoon. An estuary system in the south of the Gulf of Mexico. (Pisces: Urolophidae). An. Centro Cienc. del Mar Y Limnol. Univ. Nal. Auton. Mexico, 6(2):123-136.